

CLAIMS

- Sub B1
1. A method of path planning, comprising:
 providing a medical imaging dataset representing a cavity and a boundary;
 providing a plurality of points in said dataset, including at least a starting point and an ending point; and
 automatically determining a path between the starting point and the ending point, responsive to a penalty associated with passing through various points in the cavity.
 2. A method according to claim 1, wherein said penalty function is responsive to a morphology of the cavity.
 3. A method according to claim 2, wherein said morphology comprises a width.
 4. A method according to claim 2 or claim 3, wherein said morphology is a local morphology.
 5. A method according to any of claims 1-4, wherein said penalty function is responsive to the path.
 6. A method according to claim 5, wherein said penalty function is responsive to an amount of local bending of the path.
 7. A method according to any of claims 1-6, wherein automatically determining a path comprises automatically determining a trajectory of an origin of a viewport.
 8. A method according to any of claims 1-7, wherein providing a plurality of points comprises providing a trajectory.
 9. A method according to any of claims 1-8, wherein automatically determining a path comprises automatically determining a trajectory of an aiming point.

a 10. A method according to any of claims 1-9, wherein automatically determining a path comprises automatically determining an angular orientation of a line of sight, relative to a path traveled by a viewport origin.

a 5 11. A method according to any of claims 1-9, wherein automatically determining a path comprises automatically determining an angular orientation of a line of sight, relative to a path traveled by a viewport origin, responsive to a local width of the cavity.

12. A method according to any of claims 1-9 or 11, wherein automatically determining a path comprises automatically determining an angular orientation of a line of sight, relative to a path traveled by a viewport origin, responsive to a local bend of the path.

13. A method according to any of claims 1-10, wherein automatically determining a path comprises automatically determining at least one viewing parameter along a trajectory of a view origin point.

a 14. A method according to any of claims 1-13, wherein said penalty depends on a viewing quality possible from a point.

20 15. A method according to claim 14, wherein said viewing quality depends on human perceptual abilities.

a 16. A method according to claim 14 or claim 15, wherein said viewing quality depends on a specific task to be performed with said path.

25 a 17. A method according to any claims 1-16, comprising smoothing the path.

18. A method according to claim 17, wherein said smoothing is dependent on a local width of the cavity, at the smoothed portion of the path.

30 a 19. A method according to any of claims 1-18, comprising automatically repeating at least said automatically determining a path between said starting and ending points.

a 20. A method according to any of claims 1-19, comprising providing at least one user-provided limitation on said path determination.

Ant Bl 21. A method according to claim 19, wherein automatically repeating comprises automatically repeating automatically determining a path, responsive to at least one user-provided limitation.

a 22. A method according to claim 20 ~~or claim 21~~, wherein said at least one limitation comprises a rigid limitation.

a 23. A method according to any of claims ²⁰~~20-22~~, wherein said at least one limitation comprises a flexible limitation.

a 24. A method according to any of claims 20-23, comprising indicating to a user which limitations are not met.

a 25. A method according to any of claims 1-24, comprising selecting a data granularity level for said path determination.

a 26. A method according to any of claims 1-25, wherein automatically determining a path comprises evaluating a penalty function for the points.

27. A method according to claim 26, wherein said penalty function is dependent on the distance of the point from a boundary of the cavity.

28. A method according to claim 27, wherein said penalty function is lower for points which are further from the boundary.

29. A method according to claim 28, wherein said penalty function has a substantial rate of increase when approaching said boundary.

a 30. A method according to claim 28 ~~or claim 29~~, wherein said penalty function has a low rate of change away from said boundary.

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- a 31. A method according to any of claims ~~27-30~~, comprising determining said distance by erosion of the dataset.
- a 32. A method according to any of claims ~~27-30~~, comprising determining said distance by wave propagation from the boundaries of said cavity.
- a 33. A method according to any of claims ~~1-32~~, wherein said determining a path comprises determining a relatively short path.
- 10 ~~34. A method according to claim 33, wherein a relatively short path comprises a shortest path which takes into consideration the penalty value associated with the various locations.~~
- a 35. A method according to claim 33 ~~or claim 34~~, wherein automatically determining a path
15 comprises generating a graph representing at least a portion of the cavity.
36. A method according to claim 35, wherein said path is determined by applying a path finding method to the graph and wherein said portions of said graph are generated only when needed by said method.
- 20 a 37. A method according to claim 35 ~~or claim 36~~, wherein automatically determining a path comprises determining a path using Dijkstra's shortest path finding method on said graph.
- a 38. A method according to any of claims ~~35-37~~, wherein said graph includes only a subset
25 of voxels in said cavity.
39. A method according to claim 38, wherein said graph comprises substantially only a skeleton of said cavity.
- 30 40. A method according to claim 39, wherein said skeleton is found utilizing data from erosion of the cavity, which erosion is utilized to determine a distance of interior points from said boundary.

a 41. A method according to any of claims 1-40, wherein said dataset is represented by voxels.

a 42. A method according to any of claims 1-41, wherein said boundary is represented by
5 polygons.

a 43. A method according to any of claims 1-42, wherein said dataset comprises a CT dataset.

44. A method according to any of claims 1-42, wherein said dataset comprises an MRI dataset.

a 45. A method according to any of claims 1-42, wherein said dataset comprises a NM dataset.

15 a 46. A method according to any of claim 1-45, wherein said boundary has small holes therein and wherein said path does not pass through holes narrower than a predetermined width.

20 47. A method according to claim 46, wherein said predetermined width is dependent on a morphology of the cavity.

48. A method of path planning, comprising:
providing a medical dataset representing a cavity having a plurality of bends and a
25 boundary;
providing a plurality of points in said dataset, including at least a starting point and an ending point;

30 automatically determining a path between the starting point and the ending point, wherein said path does not remain substantially in a medial axis of the cavity and does not approach closer than a predetermined distance to said boundary, in at least two of said bends.

49. A method according to claim 48, wherein said dataset is represented using voxels and wherein said path does not approach closer than one voxel to said boundary.

50. A method according to claim 48, wherein said dataset is represented using voxels and wherein said path does not approach closer than three voxels to said boundary.

5 51. A method according to claim 48, wherein said dataset is represented using voxels and wherein said path does not approach closer than one tenth the local width of said cavity, to said boundary.

10 52. A method according to claim 48, wherein said dataset is represented using voxels and wherein said path does pass through holes in said boundary which are narrower than a predetermined width.

53. A method of simultaneously distance determining and skeletonizing a dataset including a cavity and a boundary thereof, comprising:

15 eroding said cavity, using a series balls of increasing radius R_i ;
determining a distance of points interior to the cavity, from the boundary, utilizing said erosion;
opening said eroded cavity, for each radius R_i , using a ball of radius 1; and
accumulating the points which are removed from said eroded cavity by said opening, to
20 form a skeleton.

54. A method according to claim 53, wherein erosion by a ball R comprises eroding the result of eroding with a ball of radius $R-1$, with a ball of radius 1.

25 55. A method of path planning, comprising:
providing a dataset representing a cavity and a boundary;
providing a plurality of points in said dataset, including at least a starting point and an ending point; and
automatically determining a path between the starting point and the ending point,
30 responsive to a penalty associated with passing through various points in the cavity.

56. A method according to claim 55, wherein said penalty function is responsive to a width of the cavity.

a 57. A method according to claim 55 ~~or claim 56~~, wherein said penalty function is responsive to an amount of local bending of the path.

u₃ 58. A method according to any of claims ⁵⁵~~55-57~~, wherein automatically determining a path comprises evaluating a penalty function for the points.

59. A method according to claim 58, wherein said penalty function is dependent on the distance of the point from a boundary of the cavity.

10 60. A method according to claim 59, wherein said penalty function is lower for points which are further from the boundary.

20 a 61. A method according to any of claims ~~55-60~~, wherein said determining a path comprises determining a relatively short path.

62. A method according to claim 61, wherein a relatively short path comprises a shortest path which takes into consideration the penalty value associated with the various points.

20 a 63. A method according to claim 61 ~~or claim 62~~, wherein automatically determining a path comprises generating a graph representing at least a portion of the cavity and wherein said path is determined by applying a path finding method to the graph and wherein said portions of said graph are generated only when needed by said method.

25 a 64. A method according to any of claims ~~1-47 or 55-63~~, wherein said penalty function is responsive to an Euclidean distance of said various points from said boundary.

a 65. A method according to any of claims ~~1-47 or 55-64~~, wherein said path planning allows a path to pass through two diagonally-adjacent voxels.

30 66. A method according to claim 25, wherein said granularity is determined responsive to a morphology of said cavity.

67. A method according to claim 66, wherein a local granularity is determined and wherein said morphology comprises a local morphology.

68. A method according to claim 67, wherein said local morphology comprises a local
5 width.

69. A method according to claim 25, wherein a local granularity is determined and wherein said granularity is determined responsive to a distance of a locality from a cavity boundary.

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10 70. A method according to claim 25, wherein a first granularity is determined for a first path planning and comprising repeating said path planning using a second granularity and using said first path as a starting point for said repeated path planning.